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ABSTRACT

This document contains papers presented at a symposium which was an outgrowth of the research project examining the cognitive deficits in mentally retarded persons. The studies which are discussed were designed to demonstrate that basic cognitive tasks are capable of predicting performance on standard measures of intelligence. The subjects of the research were 141 graduating high school seniors, who were tested on 10 different tasks of cognitive ability. In addition to the 10 tasks, each S completed the Wechsler Adult Intelligence Scale-Revised and a demographic questionnaire. An introduction to the symposium by Douglas K. Detterman briefly describes the research aims and procedures. The results of each of the 10 tasks are presented in separate papers: (1) "Reaction Time, Memory Scanning, and Recognition Correlates of Intelligence" (Frances A. Conners and Douglas K. Detterman), which presents the results of the Choice Reaction Time task, the Sternberg Search Task, and the Recognition task; (2) the paper by Peter J. Legree and Douglas K. Detterman, which discusses the Tachistoscopic Threshold, Tachistoscopic Decay, Learning, and Relearning tasks; and (3) the presentation of Rolf Taylor and Douglas K. Detterman, which reports on the Stimulus Discrimination task, the Self-Paced Probe task, and the Experimenter Paced Probe task. The general purpose of the three papers is to present the data obtained from each task, compare the results obtained in this study with those generally obtained using these tasks, and, where relevant, to compare the results of this research to those obtained in a previous study. (CL)

ASSESSING COGNITIVE DEFICITS IN THE MENTALLY RETARDED

Introduction

Douglas K. Detterman

The research to be reported in this symposium is a continuation of research reported here last year. Last year we presented data on nine tasks measuring basic cognitive abilities. All of these tasks had been given to 20 mentally retarded and 20 nonretarded subjects along with the WAIS-R.

The tasks we used were disigned to operationalize a model of information processing. Each task yeilded a number of parameters. Each parameter operationalized one part of the model. Though I will not discuss it in detail, this model is shown in Figure 1.

Our major aim in this research was to determine to what extent basic measures of cognitive ability are capable of accounting for differences in intelligence as measured by standard psychometric instruments. In addition, we wished to determine to what extent parameters from various tasks were interrelated.

Table 1 shows the major results obtained from last years work. Names of the parameters from each of the tasks are shown in the left column followed by a brief description of the parameter. The next column shows the split-half reliabilities of each parameter. The right-hand column shows the raw correlation of the parameter with WAIS-R IQ. Since we used an extreme groups design, these correlations are inflated by the extended range. The correlations in parentheses are corrected for extended range. These correlations are the best estimate of what would be found in a random sample drawn from the general population.

As can be seen from Table 1, correlations between the various parameters ranged from low to moderate. When multiple regression was used to obtain the best combination of variables to predict IQ, substantial prediction was obtained. The multiple R was 0.89. We concluded that it was possible to combine measures of basic cognitive ability to predict standard measures of psychometric intelligence.

A major objection to our conclusion was that since the data were obtained from extreme groups, they might not be representative of results which would be obtained from the general population. We considered this an unlikely possibility particularly since the general pattern of correlations was replicated separately within mentally retarded and nonretarded groups.

The research we are reporting this year is an extension of last years work having as its principal aim the same goal of demonstrating that basic cognitive tasks are capable of predicting performance on standard measures of intelligence. Although we feel that last years work achieved this aim, this years project was designed to be an unequivocal demonstration that elementary measures of mental function can predict more complex psychometric measures of IQ. Since Galton and Cattell set out to demonstrate that individual differences in intellectual functioning could be predicted by simple experimental measures, the failure to find such relationships has been an impediment to the development of theories of intelligence.

Although there have been moderately successful efforts to predict intellectual functioning using basic cognitive tasks, to our knowledge no one has ever been more than moderately successful in this effort. The work

of Hunt, Keating, Sternberg and others has demonstrated that it is possible to obtain at least moderate correlations of basic cognitive tasks with measures of IQ or at least specific abilities found on IQ tests. I. we are to develop good theories of individual differences in intellectual functioning, then we must know if the basic processes from which we construct our theories are, in fact, capable of predicting differences which can already be quantified using more complex IQ measures. We consider this to be such a fundamentally important question that we were willing to invest a substantial effort in answering it.

In the work to be reported we tested 141 graduating high school seniors on ten different tasks of cognitive ability. Each task was presented by a Terak 8510a microcomputer shown in slide 1. The computer was fitted with a touchscreen and all responses were made by touching the computer's screen. All instructions and verbal feedback were presented by a Votrax voice synthesizer. Correct and incorrect responses were signalled by a beep and buzz made by the computer. Because all responses were made on the touchscreen, we were able to separate decision time, the time required to decide which response to make, and movement time, the amount of time required to move to the appropriate response area. In those cases in which decision time and movement time are combined into a single measure we call it response time.

In addition to the ten tasks, each subject completed the WAIS-R and an extensive demographic questionnaire. The approximate amount of time required to complete all of this was from three and one half to six hours. Participation was about equally divided between two successive days.

Subjects generally found the tasks to be interesting and only three failed to return for the second day of testing.

All of the cognitive tasks used the same stimuli. Stimuli were 4 X 4 matrices with some squares filled. These stimuli were selected for several reasons. First, the entire population of stimuli could be specified. Second, they could be readily scaled using physical characteristics of the stimuli. Third, subjects have probably had little experience with these stimuli and hence differential familiarity should be minimized. Finally, since the stimuli are different than those found on IQ tests, any correlations that result between the tasks and IQ cannot be due to the use of common stimulus materials. Further. differential prediction of IQ by various tasks cannot be due to stimulus differences since all tasks use the same stimuli.

The ten tasks are highly familiar to most of you. Besides its standard name, we designate each task by a two-character code. These tasks will be fully described in later presentations. The tasks we used in the order in which they were presented to the subject were:

Learning - LR - an assessment of probed learning skill.

Choice Reaction Time - RT - a choice reaction time task similar to that used by Jensen.

Relearning - RL - a relearning of material originally learned in LR.

ST
The Sternberg Memory Search Task - a task designed to measure the speed of search through memory.

Probe Task - PR - a six item experimenter-paced probe memory task.

All of the above tasks were presented on the first day of participation. The folowing tasks were presented on the second day.

Self-Paced Probe Task - SP - similar to PR but the subject was allowed to determine how long each item was presented.

Stimulus Discrimination - SD - this was a six-choice match-to-sample task.

Recognition Memory - RC - a test of recognition memory for stimuli presented in previous tasks.

Tachistoscopic Threshold - TT - a deternmination of the threshold required to determine if two stimuli were the same or different.

Tachistoscopic Delay - TD - a determination of the delay required for subjects to be able to discriminate if there was a delay between the presentation of the two successively presented stimuli.

The subjects for this experiment were graduating high school seniors from a suburban public high school. We first obtained a list of all students who would be leaving the high school at the end of the academic

year. This list included students in special education classes who were leaving school. Next, each student was sent a letter explaining the experiment and requesting participation. Shortly after the letter had been sent, each subject was contacted by phone. The experiment was explained again and remaining questions were answered. If the subject agreed to participate, he was contacted again to arrange a time for participation. Subject's were not paid for participation but transportation to the laboratory was provided when needed.

There were a total of 622 students included on the original list. Of these 144 participated. Three failed to complete a portion of the experiment and were not included in the final data set. By far the greatest reason for subjects' not participating was the inability of experimenters to reach them on the phone. The second most frequent reason was that subjects had moved.

The final sample included 141 subjects. The mean WAIS-R IQ was 108.03 with a standard deviation of 18.3. While the mean and standard deviation are different from those of the normative sample for the WAIS-R they are probably representative of the suburb from which the sample was drawn. The range of IQ's included in the sample was from about 50 to 150. Although the sample was not identical to the sample used to norm the WAIS-R it was normally distributed. In fact, we believe that this sample is about as representative as it would be possible to obtain without employing extremely expensive national sampling methods.

In the following papers, you will hear brief reports on the results

from each of the ten tasks by the students who took primary responsibility for them. Fran Conners will present Choice Reaction Time - RT, the Sternberg search task - ST, and the recognition task - RC. Peter Legree will present Tachistoscopic Threshold - TT, Tachistoscopic Delay - TD, Learning - LR, and Relearning - RL. Rolf Taylor will discuss Stimulus Discrimination - SD, the Self-Paced Probe task - SP, and the experimenter paced probe task - PR. The general purpose of these presentations is to present the data obtained from each task, compare the results we obtained with those generally obtained using these tasks, and, where relevant, to compare the results to those obtained last year.

The first presentation is by Fran Conners.

Reaction Time, Memory Scanning, and Recognition Correlates of Intelligence

Frances A. Conners and Douglas K. Detterman

Case Western Reserve University

One of our tasks was a choice reaction time task. Its purpose was to provide some indexes of processing speed, which has been related to intelligence by many researchers.

The choice reaction time paradigm we used requires subjects to respond as quickly as possible to the onset of one of up to 8 stimuli. In each trial, a set of 1, 2, 4, 6, or 8 stimuli, arranged along a semicircle, is presented to the subject. One of the stimuli then lights up, and the subject quickly responds to that stimulus. Reaction time is plotted against bits of information (derived from the minimum number of alternatives in each set size). This slope tends to be positive, because reaction time increases as the number of stimuli to attend to increases. The y- intercept of this slope measures any processes not included in the reaction time measure, presumably the time it takes to encode the stimulus and prepare to respond.

In our experiment, the subject initiated a trial by touching a rectangular bar at the bottom of the screen. The stimulus set of 1, 2, 4, 6, or 8 squares then appeared. After a random interval of 2, 3, or 4 seconds, one of the squares lit up and the subject responded by touching that square as quickly as possible.

The task consisted of 9 practice trials and 120 experimental trials. Trials were blocked such that one square was displayed first, for 24 consecutive trials, followed by 2 square displayed for 24 trials, and so on. Last year trials were completely randomized and unblocked, and our measures turned out to be very unreliable. This time we blocked trials and reliabilities were much higher.

Decision time and movement time were recorded on each trial and compiled separately for each set size. Then we computed means, medians, standard deviations, slopes, and intercepts of both decision time and movement time.

Once this was done, our first step was to check the reliabilities of these variables. If they weren't reliable, their correlations with IQ and with other variables would be affected. We calculated split half reliabilities for 14 original variables. Means proved to be more reliable in general than medians, so medians were excluded from further analyses. Of the remaining variables, listed in Table 2, over half had reliabilities in the 80's and 90's. The most unreliable variable was decision time slope (.61).

Next, did we replicate previous findings? For this analysis, we combined the summarized data from all subjects. As expected, the mean slope of decision time by bits of information was positive and the mean slope of movement time was near zero, with an intercept lower than that of decision time slope. Thus, the classic finding that reaction time increases as decisions become more complex was replicated.

Which Reaction Time variables correlated with IQ scores? We

were particularly interested in the overall mean and standard deviation of decision time and the slope and intercept of decision time by bits of information. All of these variables except dt slope correlated with IQ. Decision time slope was the variable with low reliability and this may have contributed to the low correlation. However, -.04 is nevertheless extremely low. The variables which predicted IQ best were mean decision time and mean movement time (both -.32). In the choice reaction time task, then, overall speed of response, regardless of choice complexity, was most indicative of intelligence.

Another processing speed ability relevent to intelligence is short term memory scanning. Several investigators have found that memory scanning differences exist between groups of different intelligence levels. There is correlational evidence now as well.

In Saul Sternberg's memory search paradigm, memory sets of various sizes are briefly presented, followed by a probe stimulus. The subject is to indicate whether or not the probe was a member of the previous memory set. Memory scanning rate is reflected by the slope of reaction time by set size. The intercept of this slope represents time not associated with memory scanning, and has been equated with encoding speed. In our task fixed set procedure was used, whereby the four memory sets (1, 2, 3, and 4 stimuli) remained constant throughout the task. Based on previous findings, we expected faster scanning and faster encoding in people of higher intelligence.

In addition to the memory sets, 2 sets of probe stimuli were

used. Probe stimuli which matched the memory set stimuli made up the 'positive (matching) set' of probe stimuli. Distractors, not matching memory set stimuli, made up the 'negative set' of probe stimuli.

To begin a trial, the subject touched the bar. A warning tone was made, and then the memory set stimuli appeared across the top of the screen, one at a time, for 1.5 seconds each. Immediately following, a 'probe' stimulus was displayed in the center of the screen. Subjects were instructed to touch the 'same' response indicator if the probe stimulus was the same as one of the memory set stimuli displayed on that trial and to touch the 'different' response indicator if it was different from all of them. They were to make their responses as quickly as possible.

There were 32 practice trials and 144 actual trials. Trials were blocked and ordered according to memory set size.

We calculated means, medians, standard deviaitons, slopes, and intercepts of decision time and movement time spearately for positive and negative sets. There was a total of 32 measures. We computed split half reliabilities and threw out unreliable ($r < .50$) and redundant variables. Again, means were generally more reliable than medians, so medians were thrown out. A total of 16 variables was selected, 8 with reliabilities in the 80's and 90's. These are listed in Table 3.

One problem we had with this task last year was that, for the largest memory set, mentally retarded subjects performed phenomenally fast with a very high error rate. We suggested that

they probably began to guess impulsively when the task became too difficult. This year, we used simpler stimuli and the error rate was kept sufficiently low (mean % errors = 5.52 %). Also, Sternberg's original results were replicated. First, decision time slopes for positive and negative sets were positive, indicating a serial search through items in memory. Second, these two slopes were parallel to eachother, indicating an exhaustive search. And, as expected, movement time slopes were relatively flat and their intercepts were considerably lower than decision time intercepts.

Looking at correlations with IQ, we were especially interested in the means and standard deviations of decision time and the slopes and intercepts of decision time by set size (scanning and encoding). Mean decision time, standard deviation of decision time, and encoding speed correlated with IQ scores. Decision time slopes were borderline. Correlations of positive set slopes were barely significant (-.15), whereas those of negative set slopes fell just short of statistical significance (-.10). The best predictor of IQ in the Sternberg task was the number of trials performed (-.49), a measure of errors, suggesting that in memory scanning, response accuracy is the ability most closely related to intelligence. However, with mean percent errors at 5.52%, the high correlation was probably produced by outliers who made a lot of errors. Mean decision time for positive (-.42) and negative (-.44) sets were also good predictors, indicating that, errors aside, general decision time, rather than scanning speed, is most indicative of intelligence in this task.

Finally, we used an additional task which has less often been related to intelligence measures. This was a recognition memory task given after all but two of the other tasks had been completed.

The recognition memory task presented subjects with two stimuli on each trial. One was a stimulus which had appeared in one of the tasks already completed by the subject. The second was always a distractor that had not been used in any other task. The subject was to indicate which stimulus had been seen before by touching that stimulus.

Two practice trials and 24 actual trials made up the task. For each subject, percent correct, median dt, median mt, and median response time (dt and mt combined) were calculated. Split half reliabilities for the four variables proved to be quite good. Only percent correct was below .90 (See Table 3).

The mean percent correct was slightly over 90 %, indicating that the task was easy for most subjects. However, the range of this variable was 62.5 %. There were probably one or a few subjects who performed poorly and many who performed well. The ranges for other variables were also high.

Percent correct, possibly because of outliers, and most measures containing decision time correlated significantly with IQ. This suggests that recognition capacity, as well as cognitive speed, is important in intelligence.

To sum up, in the Choice Reaction Time task measures of overall speed of reaction and speed of encoding emerged as the most important components of intelligence. The slope of decision time by

bits of information did not correlate with IQ, but was also not very reliable. In the Sternberg memory search task, response accuracy and overall decision time correlated most highly with intelligence. Encoding speed and search rate for positive sets correlated less highly. Finally, in the Recognition memory task, recognition capacity and recognition speed were found related to intelligence, although the correlations were seemingly caused by outliers who performed poorly. In all three tasks, speed and encoding accuracy proved to be key correlates of intelligence.

SYMPOSIUM

ASSESSING COGNITIVE DEFICITS IN THE MENTALLY RETARDED

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Tables and Figures

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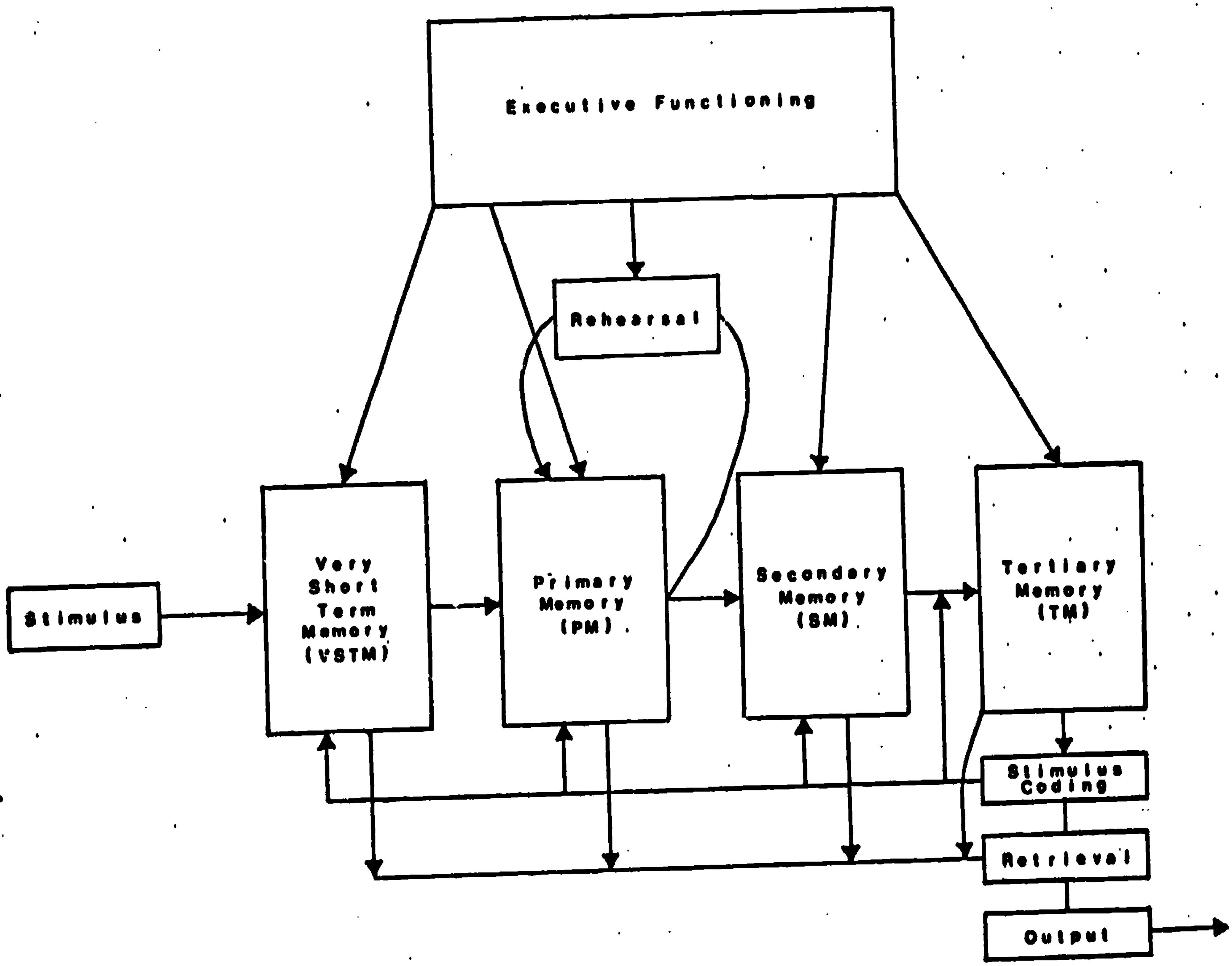

Figure 1. A composite model of cognitive functioning after Ellis and others.

TABLE 1: Rehabilities and Correlations with WAIS-IQ for Selected Measures from Cognitive Tasks

Label	Name	Rel.	r(IQ)
	Tachistoscopic Recognition		
TPPROP	OVERALL PROPORTION CORRECT	.78	.61(.40)
	Tachistoscopic Threshhold		
TFMEAN	MEAN THR. TIME	.90	-.68(-.46)
TFMED	MEDIAN THR. TIME	.67	-.61(-.40)
	Sternberg Search Task		
STDPM	MEAN D.T., POS TRIALS	.47	-.65(-.42)
STDPS	SLOPE D.T. BY SET SIZE, POS	.94	.52(.32)
STDPI	Y-INTER. D.T. BY SET SIZE, POS	.95	-.58(-.37)
STDAI	Y-INTER. D.T. BY SET SIZE, NEG	.95	-.62(-.41)
STEP	ERROR RATE, POS SET TRIALS	.58	-.65(-.43)
STEA	ERROR RATE, NEG SET TRIALS	.95	-.68(-.46)
	Choice Reaction Time		
RTMEAN	MEAN D.T.	.99	-.47(-.29)
RTYINT	Y INTERCEPT OF CORRECT	.93	-.48(-.29)
RTSLOPE	SLOPE OVER BITS OF INFO	.30	-.05(-.03)
RTSD	S.D. OF D.T., NO ERRORS	.65	-.36(-.21)
RTERRORS	D.T. OF ERRORS	.98	-.22(-.13)
	Stimulus Discrimination		
SDDT	MEAN DECISION TIME	.99	-.70(-.48)
SDMT	MEAN MOVEMENT TIME	.96	-.44(-.27)
SDERROR	NUMBER OF ERRORS	.84	-.32(-.19)
	Self-Paced Probe Task		
SPERROR	NUMBER OF ERRORS	.98	-.87(-.70)
SPDTANS	TIME TO ANSWER	.97	.59(.38)
SPDTALL	MEAN LOOKING TIME	.99	.34(.20)
SPSDALL	S.D. OF LOOKING TIME	.95	.18(.10)
	Probe Task		
PRERROR	NUMBER OF ERRORS	.96	-.78(-.57)
PRBIAS	CHI SQUARE BIAS	.87	-.78(-.57)
PRSM	ERRORS POSITION 1 & 2	.96	-.72(-.50)
PRPM	ERRORS POSITION 5 & 6	.89	-.69(-.47)
	Learning Task		
LRTRIAL	NUMBER OF TRIALS	.99	-.85(-.67)
LRTIME	MEDIAN CORRECT TIME	.96	.36(.21)
LRBIAS	CHI SQUARE BIAS	.84	-.56(-.36)
	Retention (Memory)		
MYTRIAL	NUMBER OF TRIALS	.99	-.84(-.66)
MYTIME	MEDIAN CORRECT TIME	.56	.29(.17)
MYBIAS	CHI SQUARE BIAS	.75	-.55(-.36)

Correlations in () are corrected for extended range but not for unreliability of measurement.

TABLE 2
Choice Reaction Time Task (RT)

Variable	Description	Mean	SD	Rel	r(IQ)
RTDT	Mean decision time	.442	.078	.94	-.32
RTSD	SD of decision time	.205	.136	.66	-.16
RTMT	Mean movement time	.216	.050	.90	-.32
RTDSLP	Slope of decision time by bits	.020	.030	.61	-.04
RTDINT	Intercept of dec time by bits	.408	.097	.84	-.24
RTMSLP	Slope of movement time by bits	.007	.020	.65	-.01
RTMINT	Intercpet of mvt time by bits	.204	.054	.82	-.30
RTMEDT	Median trial time	4.623	.325		-.08
RTMNT	Mean trial time	3.846	.899		-.09
RTSDT	SD of trial time	2.523	1.215		-.13

TABLE 3
Sternberg Memory Search Task (ST)

Variable	Description	Mean	SD	Rel	r(IQ)
STPDT	Mean decision time, positive sets	.732	.178	.94	-.42
STPDSD	SD of decision time, positive sets	.322	.194	.59	-.33
STNDT	Mean decision time, negative sets	.756	.186	.97	-.44
STNDSD	SD of decision time, negative sets	.319	.222	.83	-.40
STMPT	Mean movement time, positive sets	.361	.604	1.00	-.21
STPMSD	SD of movement time, negative sets	.483	3.294	1.00	-.19
STNMT	Mean movement time, negative sets	.276	.092	.88	-.34
STNMSD	SD of movement time, negative sets	.192	.161	.58	-.27
STPDSL	Slope of decision time, positive sets	.070	.056	.53	-.15
STPDIN	Intercept of decision time, pos. sets	.557	.173	.70	-.31
STNDSL	Slope of decision time, negative sets	.061	.068	.72	-.10
STNDIN	Intercept of decision time, neg. sets	.604	.218	.81	-.30
STPMSL	Slope of movement time, positive sets	.002	.233	.98	.13
STPMIN	Intercept of movement time, pos. sets	.355	1.175	1.00	-.17
STNMSL	Slope of movement time, negative sets	.014	.044	.75	-.28
STNMIN	Intercept of movement time, neg. sets	.242	.126	.76	-.01
STNTRIAL	Number of trials performed	151.940	17.43		-.49
STMEDT	Median trial time	6.045	.380		-.33
STMNT	Mean trial time	8.087	1.001		-.25
STSDT	SD of trial time	21.886	3.208		-.29

TABLE 4
Recognition Memory Task (RC)

Variable	Description	Mean	SD	Rel	r(IQ)
RCPC	Percent correct	.903	.096	.68	.41
RCDT	Median decision time	.849	.602	.96	-.23
RCMT	Median movement time	.655	.539	.96	-.03
RCRT	Median response time	1.505	.369	.89	-.34
RCMEDT	Median trial time	3.190	.525		-.30
RCMNT	Mean trial time	3.846	.899		-.23
RCSD	SD of trial time	2.048	3.118		-.09

TABLE 5
Tachistoscopic Threshold Data

Variable	Description	Mean	SD	Rel	r(IQ)
TTTHMD	Median Threshold Time	.039	0.028	0.822	-.570
TTMDDC	Median Decision Time	.169	0.132	0.989	-.024
TTCRDC	Median Decion Time for Correct Trials	.164	0.126	0.985	-.017
TTWRDC	Median Decision Time: Incorrect Trials	.207	0.214	0.963	0.020
TTMDMV	Median Movement Time	.357	0.136	0.989	0.015
TTCRMV	Median Movement Time: Correct Trials	.352	0.131	0.984	-.001
TTWRMV	Median Movement Time: Incorrect Trials	.403	0.173	0.879	0.141
TTMDRT	Median Response Time = DT plus RT	.568	0.165	0.984	-.085

TABLE 6
Tachistoscopic Delay Data

Variable	Description	Mean	SD	Rel	r(IQ)
TDTHMD	Median Threshold Time	.113	0.043	0.690	-.512
TDMDDC	Median Decision Time	.098	0.077	0.953	-.109
TDCRDC	Median Decision Time: Correct Trials	.095	0.072	0.921	-.104
TDWRDC	Median Decision Time: Incorrect Trials	.106	0.105	0.945	-.033
TDMDMV	Median Movement Time	.323	0.181	0.988	-.280
TDCRMV	Median Movement Time: Correct Trials	.315	0.180	0.982	-.285
TDWRMV	Median Movement Time: Incorrect Trials	.342	0.192	0.962	-.235
TDWRRT	Median Response Time = DT plus RT	.513	0.213	0.975	-.298

TABLE 7
Learning Data

Variable	Description	Mean	SD	Rel	r(IQ)
LRSVNG	Number of blocks attempted	13.3	4.384	0.239!	0.574
LRMDRT	Median Reaction Time	4.18	0.538	0.956	-.133
LRMDTR	Median Trial Time	0.76	0.415	0.957	-.201
LRPCOR	Percent of trials which were correct	0.54	0.159	0.967!	0.535

TABLE 8
Relearning Data

Variable	Description	Mean	SD	Rel	r(IQ)
RLSVNG	Number of blocks attempted	19.1	5.537	0.373!	0.583
RLMDRT	Median Reaction Time	0.60	0.510	0.924	-.182
RLMDTR	Median Trial Time	3.74	0.835	0.935	-.216
RLPCOR	Percent of trials which were correct	0.63	0.145	0.967!	0.427
SAVTRL	Savings based on Trials Saved	1.91	0.727	!!	-.417
SAVPC	Savings based on Percent Correct	2.24	0.364	!!	-.221

! estimated from a related measure
!! can not be calculated

TABLE 9
Stimulus Discrimination (SD) Task

Variable	Description	Mean	SD	Rel	r(IQ)
DTMEAN	Mean decision time	2.476	0.836	.69	-.39
MTMEAN	Mean movement time	0.418	0.062	.71	-.14
ERRORS	Number of missed trials	4.071	4.605	.52	-.22

TABLE 10
Self-Paced Probe (SP) Task

Variable	Description	Mean	SD	Rel	r(IQ)
MTRLTM	Mean trial time	50.752	17.263	.97	.30
SDTRTM	Standard dev of trial time	16.568	10.102	.82	.34
MLOOK	Mean looking time all posit	3.414	1.795	.97	.21
SDLOOK	SD of looking time all posit	3.200	2.028	.88	.21
PROPCOR	Proportion correct all posit	0.666	0.205	.96	.65

TABLE 11
Probed Recall (PR) Task

Variable	Description	Mean	SD	Rel	r(IQ)
PROPCORF	Proportion correct first 3 posit	0.386	0.143	.69	.48
PROPCORL	Proportion correct last 3 posit	0.576	0.129	.68	.48
PROPCOR	Proportion correct all positions	0.481	0.116	.80	.57
DTMEANF	Mean decision time first 3 posit	1.971	0.533	.90	-.08
DTMEANL	Mean decision time last 3 posit	1.733	0.583	.92	-.21
DTMEAN	Mean decision time all positions	1.852	0.540	.96	-.15
DTDEVF	SD of decision time first 3 posit	0.963	0.984	.75	-.18
DTDEVL	SD of decision time last 3 posit	0.961	0.982	.87	-.22
DTDEV	SD of decision time all positions	0.992	0.957	.95	-.21

ASSESSING COGNITIVE DEFICITS IN THE MENTALLY RETARDED

Douglas K. Detterman, Chair

Model 1:

Number of abilities = 1

$$t = w_i g + E_i$$

$$IQ = \sum_{i=1}^{n \text{ tests}} (w_i g + E_i)$$

Model 2:

Number of abilities = finite

$$t = A_i + E_i$$

$$IQ = \sum_{i=1}^{n \text{ abilities}} (A_i + E_i)$$

Model 3:

Number of abilities = large to infinite

$$t = A_i + E_i$$

$$IQ = \sum_{i=1}^{n \text{ elements}} (A_i + E_i)$$

ASSESSING COGNITIVE DEFICITS IN THE MENTALLY RETARDED

Douglas K. Detterman, Chair

$$r_{xy} = \frac{\ell}{\sqrt{(\ell + m)(\ell + n)}}$$

ℓ = abilities shared by x and y

m = abilities unique to x

n = abilities unique to y

Let x be the criterion measure, IQ, and let y be a single measure of a basic ability, t. If t measures a unique, independent ability and if IQ, contains all such independent abilities and all abilities have equal weight, then:

$\ell + m = N$ Where N = number of independent abilities

$$r_{IQ \times t} = \frac{\ell}{\sqrt{N(1 + n)}}$$

$n = 0$ Since t contains only 1 ability

$$r_{IQ \times t} = \frac{\ell}{\sqrt{\ell N}}$$

$\ell = 1$ Since only one ability is shared in common by IQ and t

$$r_{IQ \times t} = \frac{1}{\sqrt{N}}$$

Gatlinburg Part1 1984 TT

Peter J. Legree and Douglas K. Detterman

Two tasks were included in this project which attempted to operationalize very short term visual processes. The first of these was a Tachistoscopic Threshold task. This task was composed of twenty blocks of trials. Each block used an ascending method of limits to determine the Threshold Time needed to accurately discriminate two simultaneously presented stimuli as the same or different.

A block was composed of a variable number of trials and ended when the subject responded correctly to four consecutive trials, If the subject responded incorrectly on a particular trial, the presentation time on the following trial was lengthened by 17 msecs. When the subject responded correctly to a trial, the following trial had the same presentation time. A block ended when the subject was correct on four consecutive trials. The next block of trials then commenced. The threshold time value for each block was the last presentation time. The presentation time of the first trial of the the next block of trials was then reset to 17 msec.

SLIDE. The computer cued the subject to begin a task by presenting the bottom half of this display, The subject initiated the trial by pressing the bar. The cross then appeared, followed by the two stimuli. As I have just described, the stimuli were present for a variable length of time. A mask ended the presentation. The subject then indicated his answer by responding

to the display.

The computer recorded the presentation time of the stimuli and whether the response was correct. In addition to Threshold Time, the Decision Time, the Response Time and the Trial Time for each trial were recorded. The time measurements were analized seperately for the correct and the incorrect trials.

Split half reliabilities for the movement and decision time variables indicated that these variables were moderately to highly reliable with a range of reliability coefficients from 0.86 to 0.99. All of these variables correlated only slightly with the Wechsler IQ scores, the range being from near 0 to 0.141. The intercorrelations of these measures with each other indicated that the Decision Time Variables intercorrelated highly as did the various Movement Time variables and that these two groups correlated at a low level with Intelligence.

The incorrect responses were slower then correct responses for Decision Time, Movement Time, and Reaction Time.

The split half reliabilities for the Median Threshold Time variable was 0.822. The Median Threshold Time variable correlated 0.570 with the Wais-R IQ scores. This closely replicates our earlier findings that the correlation between this variable and inteliigence was between -0.524 in the retarded

group, -0.538 in the non-retarded group and - 0.608 when the two groups were combined.

The results of this task indicate that individual differences in the encoding and comparison of briefly presented stimuli is related to intelligence. This finding, coupled with our earlier data, indicates that the relationship holds across individuals in the normal range of intelligence, as well as at both the extremes of the distribution. In other words this process does not act as a threshold, beyond which the visual processes are unrelated to intelligence. The data also indicate that in this task DT and MT measures are related to intelligence and each other at only a low level.

It should be pointed out that the Tachistoscopic task incorporated a mask. The mask had the effect of interrupting the processing of information and the correlations which were observed in that data, resulted because the less intelligent individuals have processed less information. Thus whereas that task measured differences in the encoding of visual information it was dependant upon the effect of the mask.

The second task was named Tachistoscopic Delay, and was designed to investigate the Very Short Term Visual processes of people independently of the masking effect. This task first flashed a stimulus in one position and after 200 msec wrote over that stimulus with blank space. Next, an identicle stimulus appeared in an adjacent position either synchronously or asynchronously with the disappearance of the first stimulus. The subject had to indicate whether the the events had been synchronous or asynchronous. It was expected that the Asynchrony time would correlate negatively with intelligence.

This measure was named Visual Decay. In addition to this measure, the Decision Time, the Response Time and the Trial Time were recorded for each trial. The Time measurements were analyzed seperately for correct and incorrect trials.

This task was composed of a maximum of twenty blocks of trials. Each block used an ascending method of limits to determine a Threshold Decay Time value for that block of trials.

Because a block only ended after a subject responded correctly to four consecutive trials, each block was composed of a variable number of trials. All the trials were either synchronous or asynchronous; the only differences between trials lay in the stimuli which were used and in the time interval of asynchronous trials. If the subject responded incorrectly on an asynchronous trial, the Offset-Onset Asynchrony, on the following asynchronous trial was lengthened by 34 msecs. If the subject responded correctly on any trial or incorrectly on a synchronous trial then the following asynchronous trial had the same Stimulus Onset Asynchrony. When the subject responded correctly to four consecutive trials a block ended, The Visual Decay value for each block was the last asynchrony time interval. The next block of trials then commenced and the asynchrony time interval of the first trial of the the next block was reset to 34 msec.

SLIDE. The computer cued the subject to initiate a trial by displaying the bottom half of this display. When the subject pressed the bar, a fixation point, appeared for 500 msec. Then the screen became blank for 500 msec, after which time one stimulus appeared for 200 msec and then was written over by blank space. Next the second stimulus appeared either very shortly after the offset of the first stimulus or after a short delay as described above.

The second stimulus appeared for 200 msec and was written over by a mask. The subject then indicated whether the two events were synchronous. In all cases the two stimuli were identical.

For each trial, the computer recorded the asynchrony time of the stimuli, whether the response was correct and the correct response. The variable, Visual Decay variable, was operationalized as the last asynchrony time during a block. In addition to these recordings the Decision Time, the Response Time and the Total Trial Time of each trial were recorded. An additional measure, **Response Time was calculated by adding Decision and Response Time for each trial. The time measurements were analized seperately for both correct and incorrect trials.**

The data from this task indicated that all the time measurements and the threshold measurement from this task were extremely reliable, with a range of reliability from 0.81 to 0.99. As in the other Tachistoscopic task, the time measurements including Decision Time, Movement Time and Reaction Time, correlated at a low level with intelligence while the threshold variable, Visual Decay, correlated moderately with intelligence, 0.51.

It was expected that the two Tachistoscopic measurements would intercorrelate at a very high level. The observed intercorrelation was moderately high, 0.47. This intercorrelation is difficult to interpret, a higher intercorrelation would have indicated a VSTM factor and would have

helped substantiate at least part of the model which Detterman had originally proposed. A lower intercorrelation would have indicated that the Very Short Term Visual processes are composed of at least two independent components. More likely, these tasks measured a number of Very Short Term Visual processes, some of which overlapped.

Gatlinburg 1984 Learning and Relearning

The next two tasks had the goal of measuring Individual Differences on two learning tasks and relating these differences to intelligence.

The first task was named the Learning Task. This task was a Probed Learning task which contained four blocks of trials. Within each block, the computer repeated the presentation of the stimuli until the subject was correct on all the probes of one trial or until the subject had received ten trials. The major differences between the blocks lay in the set size which varied dramatically over the four blocks. The four block used 3, 5, 7 or 9 stimuli. As the subjects progressed through the blocks in an ascending order of difficulty, the computer monitored the performance of the subject and terminated the task after the first, second or third block of trials if the performance of the subject fell below a specified criterion. In this manner the subject's level of frustration was minimized and the subject's time was utilized efficiently.

SLIDE. At the start of each block, the computer cued the subject to attend to the screen by presenting this display, of course the number of open windows varied depending upon the set size of the particular block. A beep was then sounded by the computer. Two seconds later a stimulus appeared in the left most position for one second. This stimulus flashed off and a

stimulus appeared in the second open window for one second, and so on for the remaining windows. In this manner all the stimuli were sequentially presented for one second each, to the subject.

SLIDE. After the last stimulus had flashed off, all the stimuli which had appeared during the presentation were sequentially presented in the probe window. The subject's task was to point to where the probe had appeared. The stimuli were probed in a pseudorandom order.

If the subject was incorrect on any of the probes of a trial, the computer repeated the trial. The only difference between the trials of a block was the order in which the stimuli were probed. Trials were repeated until either the subject was correct on all the probes of one trial or until the subject had received ten trials. The next block of trials was then begun.

Learning was assessed on this task by two related measures. The first method simply calculated the number trials which the subject did not receive because he learned the stimuli and the computer terminated a block before all ten trials were presented. According to this method, high values indicate a high level of learning, while low values indicate little learning. This measurement correlated 0.57 with intelligence.

The second method used to measure learning calculated the percent of the probes which were correctly responded to. This method involved counting the

number of correct responses and correcting this value for trials on which the subject would have been correct but that were not attempted. This variable produced a correlation of 0.53 with intelligence.

Not surprizingly these two measurements were moderately intercorrelated.

The second learning task was appropriately named Relearning. This task was identical in all major respects to the first learning task, including the actual stimuli which were used. The only difference between the tasks lay in the instructions which were altered and in the fact that the Relearning task always followed the Learning task and was temporally seperated from the Learning task by the Reaction Time task. The Reaction Time task was chosen for this purpose because it has a fixed number of trials and therefore takes roughly the same amount of time for all the subjects, and because it does not utilize any stimuli thereby minimizing Interference.

The measusements which were taken on this task included those of the Learning task. The first learning variable, trials not completed correlated 0.58 and the second learning variable, Percent Correct correlated 0.59 with intelligence.

Two additional measures were produced from the Learning and the Relearning task which measured Savings. The first measure of Savings divided the sum of the number of trials not presented on the Learning and on the Relearning Task

by the number of trials not presented on the Learning Task. This measurement correlated 0.417 with the Intelligence scores. The second measure used the same process on the percent correct. This measurement correlated 0.221 with the Intelligence scores.

The intercorrelations of the variables between these two tasks indicate that the savings and learning variables were all intercorrelated. The results indicate that Learning, as operationalized in this task, is related to intelligence.

SD

STIMULUS DISCRIMINATION

Rolf Taylor and Douglas K. Detterman

In the proposed Information Processing model stimulus identification was one of the first processes to occur. To assess discrimination ability a six stimulus match-to-sample task was employed. On each trial six of the 24 stimuli were presented. A probe was presented centered over the horizontal row of six stimuli. The probe matched one of the stimuli. The subject was to find the one that matched and to touch it. A trial was begun when the subject touched the home rectangle, or 'bar', at the bottom of the screen. A warning tone was sounded, followed by the display. The display remained until the subject removed his/her finger from the the bar, at which time the stimuli changed to empty 4 X 4 matricies. The subject then touched the position which had matched the probe. After the response, feedback of a beep for correct, or a buzz for incorrect, was given.

The following instructions accompanied a demonstration trial, and were given by the speach synthesizer: "TOUCH THE BAR PLEASE. (the computer paused until subject responded) LOOK AT THE SQUARE AT THE TOP OF THE SCREEN. FIND THE ONE IN THE ROW THAT LOOKS THE SAME. TOUCH THE ONE THAT LOOKS THE SAME. (the computer then waited for a response from the subject) LEAVE YOUR FINGER ON THE BAR UNTIL YOU FIND THE ONE THAT LOOKS THE SAME. NOW TRY THESE FOR PRACTICE. (three practice trials were given) NOW HERE ARE THE REAL ONES. TOUCH

THE BAR TO BEGIN." A minimum of 72 trials followed. Each stimulus appeared as the probe three times, appearing once in position 1 or 2, 3 or 4, and 5 or 6. The distractor stimuli were were randomly chosen from the other stimuli in the set. Incorrectly answered trials were reinserted at a randomly chosen point later in the sequence. In this way errorless data for all stimuli was obtained.

The mean Decision Time and Movement Time were calculated for each subject, as were the standard deviations for these variables. These were calculated using correct trials only. The number of errors (trials needing to be repeated) was also calculated. Reliable variables were analyzed across all 141 subjects with the results shown in Table 9. The reliabilities of the standard deviations of Movement Times and Decision Times were low, thus these variables were excluded from further analysis. The reliabilities for the other three variables were between .52 and .69 . Decision Time, Movement Time, and Errors correlated with IQ -.39, -.14, and -.22, respectively. These findings are consistent with those found last year. The results of this Discrimination task indicate that both the time to discriminate, and number of errors, correlate with IQ.

SP

SELF PACED PROBE

Rehearsal serves to transfer information from a primary to a secondary memory store, where it is less prone to decay. It has been hypothesized, therefore, that short-term memory deficits may be due to rehearsal deficits. Bellmont and Butterfield found that the retarded do not spontaneously employ rehearsal strategies, but can be trained to do so. In a recall task that requires the last few items to be recalled first, the ideal strategy is one of looking at each of the first few positions, rehearsing after each one, and then rapidly viewing the last few positions. The subject can then **rapidly dump out the last items from primary memory, and then recall the rehearsed items from secondary memory.**

This task employed a seven position probed recall task. Seven blank matrices appeared on the screen. When the subject touched the 'bar' at the bottom of the screen, a stimulus appeared in the first of the seven positions. This stimulus remained until the subject again touched the bar, at which time it disapeared and a different stimulus appeared in the second position. This continued until the subject had viewed one stimulus in each position. When the subject then touched the 'bar' the stimuli then appeared in a row below the now blank positions. The fifth position then lit up and the subjects task was to touch the stimulus which had appeared there. The sixth, seventh, and first through fourth positions were then probed. Auditory feedback was given as to the correctness of each response.

Since the task depends on the ability to rehearse, the stimuli used were symmetrical, forming 'good' patterns. Previous research has shown that good patterns are more easily assigned a verbal label than are poor patterns.

The following instructions, accompanied by a demonstration trial, were given by the speach synthesizer: "TOUCH THE BAR. (the computer paused until subject responded) YOU WILL SEE A PICTURE IN EACH EMPTY SQUARE. TO SEE THE NEXT PICTURE TOUCH THE BAR. TO SEE EACH PICTURE TOUCH THE BAR. (the computer paused as the subject viewed the stimuli) NOW TOUCH THE PICTURE THAT WAS IN THIS SQUARE (another pause as the subject responded to the probe) SHOW ME WHERE THE OTHER PICTURES WERE. WHERE WERE THE OTHER PICTURES? (pause while subject responds to the rest of the probes) NOW YOU TRY IT SOME MORE. TRY AND GET THEM ALL RIGHT. TOUCH THE BAR TO SEE EACH PICTURE." This was followed by 28 test trials.

The mean time spent looking at each position was recorded and will be referred to as Looking Time. The correctness for each response was also recorded. The time spent to complete an entire trial was recorded, and will be referred to as Trial Time. Mean Looking Time and Trial Time was calculated for each subject, as was the standard deviation of these times. Proportion correct was calculated for each position, and overall. It was expected that the standard deviation of looking times would be indicative of strategy use. All variables had reliabilities of .68 or higher, most

between .88 and .95 . The correlations with IQ for mean Trial Time and mean Looking Time were .30 and .21. Standard deviation of Looking Time and Proportion Correct correlated with IQ .21, and .65, respectively. Results are shown in Table 10.

PR

PROBED RECALL

The Probed Recall task was similar to the Self Paced (SP) task, but only six stimulus positions appeared. The stimuli used were the same 24 stimuli as used in the Stimulus Discrimination (SD) task. After the subject placed his/her finger on the home bar the computer presented a stimulus in the left most position. After one second this stimulus disappeared and a stimulus appeared in the second position. This continued until a stimulus had appeared in each of the positions. At this point a stimulus appeared in the standard or probe position above the now blank stimulus matrices. The subject was to respond by touching the position where the probe stimulus had appeared. The correct stimulus then lit up to provide visual feedback.

The following instructions, accompanied by a demonstration trial, were given by the speech synthesizer: 'TOUCH THE BAR ON THE BOTTOM PLEASE (there was then a pause until subject responded) YOU

WILL SEE A PICTURE COME ON IN EACH SQUARE. TRY TO REMEMBER THE PICTURES. (the computer displayed the stimuli, and then the probe) TOUCH THE SQUARE THIS PICTURE WAS IN. WHERE DID YOU SEE THIS PICTURE? (the computer waited for a response) OK, HERE IS A PRACTICE TRIAL. TOUCH THE BAR. (one practice trial is administered) NOW TRY THESE." This was followed by 72 trials, incorrect trials were not repeated.

Mean Movement Time and mean Decision Time were calculated for each subject, across the first three, last three, and all positions. Similarly standard deviations were calculated for these variables. The proportion of correct responses also was calculated across the first three, last three, and all positions. These statistics were based on all trials including those incorrectly answered. The mean and standard deviation of Decision Time correlated with IQ -.15 and -.21, respectively. Proportion Correct correlated .57 with IQ. Results are shown in Table 11. These results confirm the findings from last years study.